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# **The Effectiveness of Cross-Currency Hedging**

Imad A. Moosa\*

La Trobe University, Australia

## **Abstract**

This study examines the effectiveness of cross-currency hedging compared to that of forward hedging and money market hedging. It is demonstrated that cross-currency hedging is not only less effective than forward and money market hedging but also that it is totally ineffective unless the exchange rate of the exposure currency and that of the third currency are highly correlated. The results indicate that for an effective cross-currency hedging a correlation coefficient of 0.50 is required. This kind of correlation reduces the variance of the rate of return on the unhedged position by about 25 per cent.

*Key words:* Cross-Currency Hedging, Correlation, Foreign Exchange Exposure

*JEL classification:* F30, G15

## **1. INTRODUCTION**

It has been suggested that cross-currency hedging can be used to cover exposure to foreign exchange risk when it is not possible or costly to engage in forward and money market hedging. Forward contracts may not be available on the currency in which the exposure is denominated (the exposure currency), either because it is an exotic, thinly-traded currency or because the exposure is of a long-term nature for which there is no matching forward contract. It may also be the case that it is not possible to borrow or lend funds denominated in the currency of the exposure, which means that it is not feasible to engage in money market hedging. Or it could be that money market hedging is expensive because it involves lending and borrowing in two currencies.

Cross-currency hedging is also related to the concept of a “natural hedge”, which arises when a firm has offsetting positions on two currencies whose exchange rates against the base currency are highly correlated. Brooks and Chong (2001) argue that although hedging currency risk with currency futures is more effective than cross-currency hedging, firms often obtain a natural hedge when they have opposite exposures to movements in two or more currencies. Jorion (2001, p 475) argues that hedging each source of risk (in this case the risk arising from each individual currency) separately is inefficient because it ignores exchange rate correlations. Brooks and Chong (2001) put forward the idea that cross-currency hedging can reduce volatility by around 15 per cent compared with 60-80 per cent when futures contracts are used. Siegel (1997) evaluates the effectiveness of cross-currency hedging by employing the cross-currency options listed on the Philadelphia Stock Exchange to extract the relationship between hedging effectiveness and the implied exchange rate correlations.

Cross-currency hedging amounts to taking an offsetting position on a third currency, such that the exchange rates of the third currency and the currency of exposure against the base currency are highly correlated. If there is a long exposure then the hedger takes a short position on the third currency and vice versa. Thus, if the exposure currency appreciates against the base currency, the third currency also appreciates (by the same percentage if the exchange rates are perfectly correlated). And since the positions on the exposure currency and the third currency are opposite, any profit (loss) made on the exposure will be offset by the loss (profit) made on the third currency position. Although the position on the third currency may involve forward, futures or options contracts, this exercise is based on offsetting spot positions, which gives the study a distinguishing feature.

The objective of this paper is to test the effectiveness of cross-currency hedging compared to that of

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\* Email: [i.moosa@latrobe.edu.au](mailto:i.moosa@latrobe.edu.au)

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forward and money market hedging using four currency combinations. This empirical exercise starts with some estimates of the optimal hedge ratios, which are subsequently used to construct hedged positions consisting of the unhedged positions and opposite positions on the hedging instrument.

## 2. METHODOLOGY

The optimal hedge ratio is measured as the slope coefficient in a regression of the rate of return on the unhedged position on the rate of return on the hedging instrument. If  $p_U$  and  $p_A$  are the logarithms of the prices of the unhedged position and the hedging instrument respectively, then the underlying regression is

$$\Delta p_{U,t} = \alpha + h \Delta p_{A,t} + \varepsilon_t \quad (1)$$

where  $h$  is the hedge ratio. In the case of foreign currency exposure  $p_U$  is the spot exchange rate between the base currency ( $x$ ) and the exposure currency ( $y$ ) measured in logarithmic form as  $s(x/y)$ .  $p_A$ , on the other hand, depends on the kind of hedging instrument used. If forward hedging is used, such that the offsetting position involves a forward contract, then

$$p_A = f(x/y) \quad (2)$$

where  $f$  is the logarithm of the forward rate. If money market hedging is used, then the price of the hedging instrument is represented by the interest parity forward rate,  $\bar{f}$ , which is the forward rate consistent with covered interest parity. Thus

$$p_A = \bar{f}(x/y) \quad (3)$$

where

$$\bar{f}(x/y) = s + \log(1 + i_x) - \log(1 + i_y) \quad (4)$$

where  $i_x$  and  $i_y$  are the interest rates on currencies  $x$  and  $y$  respectively, such that the maturity of the underlying assets is identical to the maturity of the forward contract.

Finally, if a cross hedge involving a third currency  $z$  is used the price of the hedging instrument is the spot exchange rate between  $x$  and  $z$ , in which case

$$p_A = s(x/z) \quad (5)$$

Once the hedge ratios are calculated, three positions are constructed depending on the type of the hedge used. The rates of return on the unhedged position and the three hedged positions are calculated as

$$R_U = 100[\Delta s(x/y)] \quad (6)$$

$$R_F = 100[\Delta s(x/y) - h_F \Delta f(x/y)] \quad (7)$$

$$R_M = 100[\Delta s(x/y) - h_M \Delta \bar{f}(x/y)] \quad (8)$$

$$R_C = 100[\Delta s(x/y) - h_C \Delta s(x/z)] \quad (9)$$

where  $R_U$  is the rate of return on the unhedged position,  $R_F$  is the rate of return on a hedged position involving a forward hedge,  $R_M$  is the rate of return on a hedged position involving a money market hedge, and  $R_C$  is the rate of return on a hedged position involving a cross-currency hedge.  $h_F$ ,  $h_M$  and  $h_C$  are the corresponding hedge ratios.

Consider first the effectiveness of a hedge against the alternative of leaving the underlying position unhedged. In this case, testing hedging effectiveness amounts to testing the equality of the variance of the hedged position and that of the unhedged position. The null hypothesis and the alternative are respectively

$$H_0 : \sigma^2(R_U) = \sigma^2(R_H) \quad (10)$$

$$H_1 : \sigma^2(R_U) > \sigma^2(R_H) \quad (11)$$

where  $R_H = [R_F \quad R_M \quad R_C]$  and  $\sigma^2(\cdot)$  is the variance of the rate of return on the underlying position. The null is rejected if

$$VR = \frac{\sigma^2(R_U)}{\sigma^2(R_H)} > F(n-1, n-1) \quad (12)$$

where  $VR$  is the variance ratio and  $n$  is the sample size. This test can be complimented by the variance reduction, which is calculated as

$$VD = 100 \left[ 1 - \frac{\sigma^2(R_H)}{\sigma^2(R_U)} \right] \quad (13)$$

This methodology is applied to four combinations involving four currencies. Before we proceed further, it is noteworthy that the model used to estimate the hedge ratios (equation 1) may be inadequate because (i) it excludes the error correction term; and (ii) it implies a constant hedge ratio calculated from the unconditional moments (see, for example, Kroner and Sultan, 1993; Ghosh, 1993; Lien, 1996; Brooks and Chong, 2001). However, the objective of this paper is not to measure the sensitivity of the estimated hedge ratio to model specification, but rather to compare the performance of three hedging instruments, while using the same model specification to estimate the hedge ratio. Moreover, Moosa (2003) has demonstrated that the estimated hedge ratio is not that sensitive to model specification.

### 3. DATA AND EMPIRICAL RESULTS

This empirical exercise is based on a sample of quarterly data covering the period 1974:1-2000:4, involving four currencies: the U.S. dollar (USD), the Japanese yen (JPY), the British pound (GBP) and the Canadian dollar (CAD). The variables are the spot exchange rates, the three-month forward exchange rates, and the three-month interest rates, all measured at the end of the quarter. All of the time series were obtained from the DX database (OECD Main Economic Indicators). The hedging period is taken to be one quarter, extending between the end of each quarter and the end of the subsequent quarter.<sup>1</sup> The four currency combinations are described in Table 1.

**Table 1: Currency Combinations for Cross Hedging**

Combination	Base Currency (x)	Exposure Currency (y)	Third Currency (z)
1	USD	GBP	CAD
2	GBP	USD	JPY
3	CAD	JPY	USD
4	JPY	CAD	GBP

The results of estimating the hedge ratios are reported in Table 2. Money market and forward hedging produce close hedge ratios that are not significantly different from unity. The cross currency hedge ratios are significantly different from unity, ranging between 0.311 and 0.700. The best fit (which is also a measure of hedging effectiveness) is found in case 4. It is noteworthy that the almost-perfect fit in the case of forward hedging indicates that a perfect hedge is obtained when a forward contract on the same currency is used. The almost-perfect fit in the case of money market hedging is indicative of the validity of CIP, under which forward hedging and money market hedging are equally effective.

<sup>1</sup> The use of quarterly data may be questioned on the grounds that it results in the loss of important information, which may be provided by higher frequency data. While this argument is valid, the choice of this particular frequency is warranted by the practical consideration that the settlement period in trade finance is typically longer than one month.

**Table 2: Estimated Hedge Ratios**

Case	Forward		Money Market		Cross Currency	
	h	R <sup>2</sup>	h	R <sup>2</sup>	h	R <sup>2</sup>
1	0.975	0.99	1.005	0.99	0.442	0.03
2	0.975	0.99	1.005	0.99	0.311	0.13
3	0.996	0.99	0.989	0.99	0.555	0.03
4	0.996	0.99	0.999	0.99	0.700	0.41

Table 3 reports the results of measuring hedging effectiveness. The table shows that higher risk arises from fluctuations in the exchange rate between the U.S. dollar and the pound than what arises from fluctuations in the exchange rate between the Canadian dollar and the Japanese yen. Forward and money market hedging lead to a significant reduction in the variance in all cases, with more or less similar effectiveness. But only in case 4, do we find a significant reduction in the variance resulting from cross-currency hedging, because this case shows the highest exchange rate correlation.

**Table 3: Variances and Hedging Effectiveness**

	Variance	Variance Ratio	Variance Reduction (%)
Case 1			
$R_U$	29.14		
$R_F$	0.395	73.77*	98.6
$R_M$	0.195	149.43*	99.3
$R_C$	28.25	1.03	2.9
Case 2			
$R_U$	29.14		
$R_F$	0.395	73.77*	98.6
$R_M$	0.195	149.43*	99.3
$R_C$	25.53	1.14	12.3
Case 3			
$R_U$	43.86		
$R_F$	0.196	223.78*	99.6
$R_M$	0.630	69.62*	98.6
$R_C$	42.46	1.03	2.9
Case 4			
$R_U$	43.86		
$R_F$	0.196	223.78*	99.6
$R_M$	0.154	284.81*	99.6
$R_C$	26.23	1.67*	40.1

\* Statistically significant. The 5 per cent and 1 per cent critical values are 1.39 and 1.59 respectively.

#### 4. SOME EXTENSIONS

The results presented in Table 3 show that the correlation coefficient, the hedge ratio, the variance ratio and variance reduction are related to each other. In this section we derive these relationships analytically, then we present some results showing the dependence of hedging effectiveness on exchange rate correlation. We start

with the definition of these variables, and for the purpose of simplifying notation, let  $\rho$  and  $\sigma_{y,z}$  be the correlation coefficient between and the covariance of  $\Delta s(x/y)$  and  $\Delta s(x/z)$  respectively. Also let  $\sigma_y^2$  and  $\sigma_z^2$  be their variances respectively. Thus, we have

$$\rho = \frac{\sigma_{y,z}}{\sigma_y \sigma_z} \quad (14)$$

$$h = \frac{\sigma_{y,z}}{\sigma_z^2} \quad (15)$$

$$VR = \frac{\sigma_y^2}{\sigma_y^2 + h^2 \sigma_z^2 - 2h \sigma_{y,z}} \quad (16)$$

$$VD = 1 - \frac{1}{VR} \quad (17)$$

From equation (14) and (15), we obtain

$$h = \frac{\rho \sigma_y \sigma_z}{\sigma_z^2} = \rho \left( \frac{\sigma_y}{\sigma_z} \right) \quad (18)$$

which shows the relationship between the hedge ratio and the correlation coefficient. If  $\sigma_y = \sigma_z$ , then  $h = \rho$ , and for constant variances, the hedge ratio is proportional to the correlation coefficient.

The relationship between the variance ratio and the correlation coefficient can be derived by combining equations (16) and (18) to obtain

$$VR = \frac{\sigma_y^2}{\sigma_y^2 + \rho^2 \left( \frac{\sigma_y^2}{\sigma_z^2} \right) \sigma_z^2 - 2\rho \left( \frac{\sigma_y}{\sigma_z} \right) \rho \sigma_y \sigma_z} \quad (19)$$

which can be simplified to

$$VR = \frac{1}{1 - \rho^2} \quad (20)$$

Hence

$$VD = 1 - \frac{1}{VR} = \rho^2 \quad (21)$$

which shows that variance reduction is equivalent to the coefficient of determination of the regression of  $\Delta s(x/y)$  on  $\Delta s(x/z)$ . This is actually confirmed by the results presented in Tables 2 and 3.

Finally, we can derive the relationship between the variance ratio and the hedge ratio by combining equations (18) and (20) to obtain

$$VR = \frac{(\sigma_y^2 / \sigma_z^2)}{(\sigma_y^2 / \sigma_z^2) - h^2} \quad (22)$$

which shows that if  $\sigma_y = \sigma_z$ , then  $VR = 1/(1 - h^2)$ .

These equations can be used to demonstrate the importance of the correlation coefficient for hedging

effectiveness. If we define an effective hedge to be a hedge that produces a statistically significant variance ratio, we can calculate the value of the correlation coefficient corresponding to the variance ratio. Table 4 shows the results for sample sizes ranging between 20 and 200, assuming that  $\sigma_y = \sigma_z$ . For the sample size used in this study, a statistically significant variance ratio at the 5 per cent level requires a correlation coefficient of at least 0.50. A correlation coefficient of at least 0.60 is required if the variance ratio is to be significant at the 1 per cent level. Thus, what matters is the availability of a third currency whose exchange rate against the base currency is highly correlated with the exchange rate of the exposure currency against the base currency.

**Table 4: Correlation Coefficients Corresponding to Significant Variance Ratios**

N	VR (5%)	$\rho$	VD	VR (1%)	$\rho$	VD
20	2.12	0.73	52.8	2.94	0.81	66.0
50	1.60	0.61	37.5	1.94	0.70	48.5
100	1.39	0.53	28.1	1.59	0.61	37.1
200	1.26	0.45	20.6	1.39	0.53	28.1

## 5. CONCLUSION

This study examined the effectiveness of cross-currency hedging compared to that of forward hedging and money market hedging. By using four currency combinations it was found that cross currency hedging is ineffective unless the exchange rates between the base currency and the exposure currency and that between the exchange rate and third currency are highly correlated. The results show that for effective cross-currency hedging, a correlation coefficient of at least 0.50 is required. In the absence of a third currency that satisfies the correlation requirement, there is no point in using cross-currency hedging, and the firm will be better off remaining unhedged if forward hedging and money market hedging are not possible. The results also mean that a natural hedge will not arise unless it involves two strongly correlated exchange rates.

As a final remark it can be claimed that this paper makes some contribution to the literature because it deals with a topic that has not been dealt with extensively in the literature, particularly that it is based on offsetting spot positions. Moreover, the paper identifies the synthetic instrument used when a money market hedge is implemented.

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